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CROP AND LIVESTOCK INSECT PROBLEMS FACING CGIAR CENTRES: A PROPOSAL TOWARDS THEIR LONG-TERM SOLUTION

TAC SECRETARIAT

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A PROPOSAL BY THE INTERNATIONAL CENTRE OF INSECT PHYSIOLOGY AND ECOLOGY (ICIPE) P.O. BOX 30772, NAIROBI, KENYA, FOR COOPERATIVE PROGRAMMES WITH THE CGIAR CENTRES

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I. INTRODUCTION

1. Experience with the high-yielding varieties of cereal crops in the last few years has shown that there are serious impediments to the general adoption of new technology by the peasant farmers, who make the majority of the farming community in the less developed countries (LDCs). For instance, peasant farmers have adopted the new high-yielding seeds of rice for only one-quarter of the world's ricelands; and, even in some countries where the new rice varieties are widely grown, rice production has increased far less than was anticipated. Yet, the present food production methods can only lead to a widening gap in the total world food production and food expectation. At the July 1975 International Centres Week held in Washington, D.C., the CGIAR Centres saw the challenge as that of harnessing their collective talent to develop improved crop varieties and the relevant technology geared towards the small farmer in the LDCs; of venturing on food production in regions having adverse ecological conditions to the particular crop; and in helping the small farmer to produce more food from limited land resources.

2. A study of cropping systems in the LDCs in tropical and subtropical regions has shown that crop monoculture is rare, and that more complex systems are normally put into practice: intercropping, mixed cropping, multi-cropping, or relay-cropping. Initial analysis of farming systems by some of the CGIAR Centres has indicated that these complex cropping systems have some considerable agronomic advantages: maximisation of water use, the utilization of residual soil moisture during periods of long dry seasons, the lessening of land preparation problems associated with second-season crops, the production of higher yields under these conditions than when single-cropping is practised, and the reduction of pest losses under mixed cropping. Consequently, there is a tremendous need to invest considerable research and development effort in fashioning a new technology for the small farmer in the LDCs, while realising that he will want to continue using the more complex systems - albeit improved by innovative research.

3. The problems of livestock production in tropical and sub-tropical regions are just as difficult. Perhaps the most pervasive problem is that of livestock trypanosomiasis, transmitted by tsetse flies (Glossina spp.) in Africa, and tick-borne diseases throughout the tropics. Trypanosomiasis is a major limiting factor in livestock production, excluding 4 million square miles from animal production in Africa. It is estimated that this area alone would - if tsetse flies were eradicated from therein - support an additional population of 120 million head of cattle, producing about 1.5 million tons of meat every year, representing a value of at least U.S.$ 750 million a year. Tick-borne diseases are equally important in Africa and other tropical countries. Theileriosis, anaplasmosis, and babesiosis are all major constraints to the attainment of full productive capacity in the LDCs. Although there are long-term possibilities for effective and cheap vaccines for prophyllaxis and drugs for the treatment of the overt disease condition, vector control is a principal avenue for the efficient control of these diseases. Since acaricide resistance by ticks is becoming an actual or a looming threat, other tick control strategies are needed.

4. The International Centre of Insect Physiology and Ecology (ICIPE) has an important role to play in complimenting efforts to solve these problems.

The ICIPE recognizes that there are important applied problems in the pest management of food crops (including livestock production). But it also recognized that in several crucial cases these applied problems cannot be satisfactorily approached without further basic knowledge. The target pest species that the ICIPE has chosen for its first attack - tsetse flies, livestock ticks, sorghum shootfly, cereal stem-borers, African armyworm, and foraging termites - are all pests that have already received considerable national, regional, and international attention. Many have been the subject of practical, eradication programmes on an extensive scale over the last 70 years or so. If there were simple, direct methods for the control of these important pests they would have been found in that time and put into operation. This vital fact has persuaded the

ICIPE to approach these major pest problems with a more open strategy. Thus, the ICIPE will, in each case, explore several lines of study which hold promise as novel avenues for pest control and, which possibly together with already-tried methods, may be fashioned into a pest management programme.

5. The ICIPE is well placed to undertake this kind of work, and to respond to the needs of the CGIAR institutes in the area of pest management research. Firstly, the ICIPE is strategically located in an equatorial tropical LDC at a confluence of a high-altitude tropical area, a range of savannah eco-systems, and with access to lowland tropical areas as well as semi-arid regions. Consequently, it can tackle a range of tropical pest problems, and be in intimate communication with national and regional efforts in solving applied insect problems. Secondly, the ICIPE has already chosen, as its first target insects, pest problems that are of more than national (e.g. tsetse and armyworm), or African continental interest (e.g. cereal stem-borers and legume pod-borers). Indeed, some of these problems are of international importance (e.g. bases of plant resistance, borers, and sorghum shootfly). Thirdly, the ICIPE has realised from the very beginning that training of young scientists and technologists from the LDCs is vital to the enhancement of the scientific capabilities of these countries, which is important to any long-term, science-based solutions to development problems. Fourthly, a special strength of the ICIPE lies in its ability, through its multi-disciplinary research teams and through a network of some of the best entomological research laboratories throughout the world, to bring the resources of modern biology to bear on major pest problems as they are identified, and thus facilitate the introduction of novel methods of pest control. And, finally, the ICIPE is already a tried and an on-going research centre of high quality and capability.

6. In the course of its short history so far, certain weaknesses in the ICIPE structure and management have appeared. The ICIPE Governing Board has recently taken major decisions to change these, and at the same time to consolidate the main strengths of the ICIPE approach to development problems. These will be outlined in subsequent sections.

7. The Joint CGIAR/TAC Secretariats mounted a special mission to the ICIPE in September 1975 (see Annex 1 for details). As a result of the proposals of that mission and the recommendations of the subsequent TAC meeting in Mexico in October 1975, the TAC Secretariat requested the ICIPE management to conclude actual agreements with several CGIAR Centres for collaborative research, following appropriate negotiations on workplans and budgets. The principal outcome of the mission was to support the proposal for the ICIPE to enter into a cooperative research relationship with a number of the CGIAR Centres with the support of the CGIAR/TAC . The supporting agreements and budgets were to be worked out in early 1976.

The mission's major conclusions, later supported by the subsequent TAC meeting were as follows:

(a) It fully acknowledged that the basic theme of the ICIPE was to conduct fundamental research into the ecology and physiology of insect pests, with the longer-term possibility that such studies would elucidate suitable points of attack, perhaps for more unconventional control measures

(b) It was favorably impressed that the ICIPE - in addition to its own original projects on ticks, tsetse flies, termites, armyworms, and mosquitoes - was able to respond immediately to the original reaction of CGIAR Centres and accept new programmes of vital interest to the Centres (cereal stem-borers, sorghum shootfly, and bases of plant resistance to insect attack)

(c) The response of several Centres (IRRI, IITA, ICRISAT, ILRAD) was quite positive to the revised proposal, anticipating collaboration in an integrated approach to one or more of their outstanding pest problems

(d) It recognized the fact that the ICIPE had developed some sophisticated and independent capabilities for multi-disciplinary research which could not easily or necessarily be established elsewhere in the CGIAR system, and which could be utilized by them.

8. Over the last few months, and with the full approval of the ICIPE Governing Board, the Director of the ICIPE has concluded and signed agreements with IITA and IRRI; negotiations with ICRISAT and ILRAD are at an advanced state; and negotiations with CIMMYT have also been initiated. It is the intention of the ICIPE and the first four CGIAR institutes to initiate collaborative research programmes in January 1977, and with CIMMYT in 1978, on the following programmes:

- Bases of Plant Resistance to Insect Attack: with projects on sorghum and sorghum shootfly (ICRISAT), cowpeas and cowpea leafhoppers (IITA), and rice and brown planthoppers (IRRI)
- Cereal stem-borers (ICRISAT, CIMMYT and IITA) and legume pod-borers (ICRISAT and IITA)
- Experimental Bases for Insect Mass-rearing and Screening for Resistance: stem-borers (CIMMYT, IITA and ICRISAT) sweet potato weevils (IITA), and rice stem-borers (IRRI)
- Tsetse, especially vectorial capacity problems: ILRAD
- Research Units: all institutes.

9. Budgets have been shown in detail only for 1977 (see Appendices). Detailed budgets for 1978 (and for forecastes for subsequent years) will be submitted in March 1978 to the CGIAR/TAC Secretariats after discussions with the relevant CGIAR institutes. It is most likely that the programmes will be expanded in 1978 as a result of the experience we will gather in the initial year of this collaborative programme. It is greatly to be hoped that TAC will now be prepared to make final recommendations to the CGIAR for the latter's decision and action.

II. RESEARCH PROGRAMMES

10. The detailed research strategy and programmes of the ICIPE have been given in detail in previous documents to the TAC. Below are given brief outlines of the research projects that the ICIPE will conduct collaboratively with the CGIAR Centres, as well as those the ICIPE will do on its own. The latter are clearly indicated as "Other ICIPE Core Programmes".

11. In all those cases involving crop pest programmes, ICIPE scientific staff will initiate its collaborative programmes with the CGIARCentres by spending an entire crop season or longer at the relevant Centres acquiring background knowledge of the vast crop germplasm, the particular pest problems involved, the interaction of the crop and the relevant pest, and the agonomic milieu in which the pest problem occurs. This initial orientation will ensure that ICIPE staff become familiar with the practical problems and objectives of the Centres at an early date. The special relations that the ICIPE enjoys with ILRAD has ensured that the two institutes, geographically close together, have already a close working relationship at the technical and scientific level.

12. It is proposed that scientists from the CGIAR Centres, including their breeders and entomologists, make frequent working visits to the ICIPE to become fully acquainted with research results that could be incorporated in their various programmes related to pest management. Finally, it will be noted that there is a wide level of overlap of the crop pest programmes among the CGIAR institutes (see para. 8).

A. Bases of Plant Resistance to Insect Attack : (IRRI, IITA, ICRISAT, CIMMYT)

13. The classical technique of producing new high-yielding varieties of crops is to make selections under an "insecticidal umbrella". The release of superior, but other wise insect-susceptible, varieties in the tropics, especially under small-farmer conditions, has often led to very disappointing levels of crop performance - largely due to pest attack. This classical technique is being progressively replaced by a double strategy of making selections of resistant plants from crops under a minimum insecticide application and at the same time select for high-yielding and other requisite characteristics.

14. The first significant elite rice variety that was released for widespread distribution, and which possessed both the characteristics of high-yielding and pest-resistance, was IR20. It was released in 1969, and has since been quickly adopted by numerous farmers. This demonstrates that farmers will adopt such resistant varieties because of at least two special agronomic advantages: (a) insect resistance stabilizes crop yields, and (b) production costs are significantly lowered. Rice farmers prefer to use only small amounts of insecticides, and then only when pest damage is obvious - at which time corrective measures may be too late. As the energy crisis deepens and continues, so the price of traditional pesticides will continue to rise. Consequently, the CGIAR Centres have become to regard breeding for insect resistance as an essential part of their production-oriented breeding programmes for crops.

15. However, the techniques presently available for selecting insect-resistant plants are highly pragmatic. Experimental cultivars are grown under more or less uniform environmental conditions and inter-planted with insect-susceptible cultivars, either in the field or in some type of glasshouse, screenhouse, or greenhouse; in either case, the plants are exposed to intense insect populations, either naturally occuring in the field or artificially released in the experimental arena from mass-bred or mass-collected insect populations; the damage to the plants are scored according to a predetermined rating, and the plants showing tolerance or resistance are thus identified, assembled, and processed for further breeding work. A first step in simplifying these selection procedures would be to identify the chemical and other bases of plant resistance to each particular pest. Besides, such basic knowledge would provide a tool for the monitoring of each of the steps of a plant improvement programme, ensuring that insect-resistance is retained in the course of completing the "synthesis" of a new cultivar possessing desirable agronomic and other characteristics.

16. A closely related question is that of insect biotypes, some of which have evolved to attack crop varieties that were originally selected for their resistance to insect attack. A pertinent demonstrative example of this problem, which could have tremendous impact on pest management through the selection of insect-resistant crop varieties, is that of the brown rice planthopper, Nilaparvata lugens, which has rapidly become the most serious pest of rice in Asia. IRRI recently found that some of the rice varieties that they had developed in the Philippines and were resistant to the planthopper in that country - e.g. Mudgo and ASD7 - were susceptible to the same species of planthopper when grown in Sri Lanka and in Kerala State (in southern India). An initial study has shown that the brown planthopper can rapidly develop new biotypes able to attack previously resistant rice varieties, if these possess monogenic resistance. For instance, biotype 1 is the brown planthopper naturally found at IRRI, lives well on the susceptible rice variety TN1, but cannot develop on resistant varieties Mudgo, ASD7, and IR26 at IRRI. When, on the other hand, brown planthoppers were collected from fields intensively planted with resistant rice varieties and were then reared for several generations on resistant rice plants in a greenhouse, 3 new biotypes were found to have evolved, including one (biotype 4) that could survive on two resistant varieties, Mudgo and ASD7 (biotype 4). It may therefore be hypothesized that if only a few pest-resistant varieties of rice are intensively planted over a wide area, insect biotypes may develop, through natural selection, that can attack and thrive on formerly resistant crop varieties. Such an eventuality will probably develop very rapidly when crop resistance is governed by a single pair of genes ("monogenic resistance"); it may be slowed down considerably when the resistance is governed by two or more pairs of genes ("multigenic resistance").

17. The major question facing us is to identify the several genetic mechanisms that enable an insect pest to produce new biotypes, to identify the regulatory factors in the resistant plant variety that set off the biotypic micro-evolution, and find ways in which this process can be combated.

18. Because of the widespread interest in breeding crops for insect resistance, the attendant pest problems outlined in the present ICIPE programme is likely to develop into a major activity. It will eventually cover the major crop insect pests whose control techniques encompass the production of pest-resistant crop varieties.

19. Initially, the ICIPE will tackle the following projects:

(a) Possible chemicals (and other factors) responsible for resistance to leafhoppers (Empoasca fascialis) and thrips (Sericothrips occipitalis) in the cowpea, which take a heavy toll of cowpeas in the pre-flowering stage. Several varieties of cowpeas are now known to be resistant to these and other pests, e.g. VITA 9. Legumes are known to have a pronounced phenol defence mechanism to insect attack; and it is possible that phenols, or their precursors, may be a factor in cowpea resistance to attack by leafhoppers and thrips. (Project with IITA)

(b) The pod-borer, Maruca testulalis, is a pest of legumes (e.g. pigeon pea) all over the world, and is a principal pest of cowpea, feeding on flowers and newly developed cowpea pods. In this way, it causes an almost 100% damage. Recent observations at IITA have demonstrated that damage to maturing cowpea pods shows some varietial differences. The resistance mechanism appears to be complicated, as the varieties which are resistant at the earlier pod development stage were susceptible at later development stages, and vice versa. The ICIPE plans to establish the factors, including chemical ones, for pod-borer resistance at the various pod-development stages. (Project with IITA)

(c) The ICIPE will study the biotypic development of the brown rice planthopper (BPH) under conditions of intense pressure from resistant rice varieties of different genotypic constitution, and under mixed-cropping conditions. It will also study the ecological factors that lead to this development and eventual pest outbreaks. (Project with IRRI)

(d) The ICIPE will undertake the study of the bases of resistance of tropical lowland maize to maize stem-borers, of sorghum to stem-borers, and of sorghum to sorghum shootfly. It will also study the mechanism of seeming breakdown of this resistance when cereals are grown under mixed-cropping with legumes, sweet potato, and other crops. (Project with ICRISAT, CIMMYT and IITA)

20. This is a new programme altogether, of great interest to CGIAR Centres, and will be heavily supported by three research support units – those for Chemistry and Biochemistry, Sensory Physiology, and Histology and Fine Structure.

B. Borers (CIMMYT, IITA, ICRISAT, IRRI)

21. Stem-borers are particularly serious pests of maize and rice in the African continent. In maize alone, stem-borers can cause 25-40% yield losses in Kenya. Stem-borers have become such a major pest of rice in Iran in recent years that IRRI was requested to make a special survey of the problem in 1974. Apart from the sorghum shootfly and the sorghum midge, stem-borers are the most important insect pests of sorghum in Africa and Asia.

22. Insecticidal control is not a great success, although newer techniques of application are now being tried, e.g. the placement of encapsulated systemic insecticides (carbofuran and others) near the root zone. Breeding for borer-resistant cereals is being investigated in several Centres, although so far only tolerance or moderate resistance has turned up. A concerted effort on resistance breeding is needed, and the ICIPE can contribute effectively to this effort.

23. It is planned that the ICIPE concentrate its major efforts on ecological and physiological studies of a few, key stem-borers that are principal pests of maize, sorghum, millet and rice. It is also proposed that the major theatre for this work should be East Africa, although there will be constant reference to other stem-borer/plant complexes in other situation in other regions. The key stem-borers will be the following:

Chilo partellus (=zonellus),	the sorghum stem-borer:	In maize, sorghum, millet, and rice
Busseola fusca,	the maize stalk-borer:	In maize and sorghum
Sesamia calamistis,	the African pink borer:	In sorghum and rice
Maliarpha separatella,	the African white rice borer:	In rice.

24. The ICIPE has already made a start on this programme by initiating an investigation on seasonality and the occurreuce of a larval diapause. Seasonal development of the sorghum stem-borer, C. partellus, is synchronized with the maturation of the maize crop, and the occurrence of dry and wet seasons. With the ripening of the crop, mostly coinciding with the dry season, pupation of the larvae is retarded and their further development is arrested when they attain the last larval instar. This diapause is only broken at the onset of rainfall in the succeeding wet season. Diapause is a crucial weak link in the seasonal cycle of this pest, and probably in most other stem-borers. Knowledge of the precise factors that initiate or break this diapause is lacking. Such knowledge may give us a better tool for prognosis of stem-borer outbreaks. It could also lead to the design of a novel pest control method for these important insects.

25. The ICIPE will now develop this project into a more comprehensive programme on stem-borers of maize, sorghum, millet, and rice as indicated above. The programme will initially focus on the following problems:

(a) Seasonal life cycle and the periodicity of infestation of stem-borers in all four cereals. The project will include the study of aestivation-diapause in Chilo and other stem-borers

(b) Ecological impact of seasonality on the development and reproduction of the various stem-borers

(c) Hostplant insect relations, especially in regard to oviposition, larval feeding, and larval development. The problem of host selection (including the question of wild hostplants) will also be investigated

(d) Factors determining resistance: the dynamic state of susceptibility under different agronomic practices, the chemical basis of acceptance or rejection of plants, and the physical or biophysical properties conferring tolerance or resistance, will form part of these investigations. The programme staff will necessarily work closely with staff involved in questions of plant resistance; they will also need to work closely with plant breeders and entomologists in CGIAR Centres.

The project will be carried out in collaboration with CIMMYT, IITA, ICRISAT and IRRI.

C. Sorghum Shootfly (ICRISAT)

26. The most important pest of sorghum in the Old World is apparently the sorghum shootfly, Atherigona varia soccata; and it causes serious damage to the crop arising from the habit of the shootfly larvae in penetrating the growing point. This causes "deadhearts" in the young shoots. Although the plants generally react by producing tillers, which in turn may also be killed by larvae, the number of grain-producing panicles are reduced. Much of the base-line data on this fly is not known, thus limiting choices on control techniques.

27. The seriousness of the shootfly as a major pest of sorghum has been exacerbated by the recent attempts at introducing new high-yielding varieties. For instance, the traditional sorghum varieties in East Africa are tolerant to the shootfly, and the latter was therefore not such a major pest until the introduction and widespread cultivation of new high-yielding varieties (such as "Serena") which also happen to be susceptible to the shootfly.

28. This research programme was only initiated by the ICIPE towards the end of 1974, as a result of recommendations made by ICRISAT to the UNDP/ICIPE Policy Committee. Investigations have been focussed on field studies of the shootfly in a region of major sorghum production, Western Kenya near Lake Victoria. It is already clear from these preliminary studies that we may be dealing with a complex of 3 or more closely related species (or other taxa) that there are important wild graminaceous hosts, and that the latter may well play a vital role in the seasonal outbreaks of the insect.

29. Working closely with ICRISAT, it is proposed to undertake the following projects on the sorghum shootfly:

(a) Factors controlling the development of the fly larvae, the chief pest stage. The manner in which the host physiology, host specificity, and the plant micro-environment regulate larval development will be a major part of these studies

(b) Control of reproduction in the shootfly and a study of the fly's reproductive potential in the field. Such studies will naturally lead to the consideration of seasonality of shootfly occurrence and outbreaks

(c) Methods of sampling the adult population

Responses of larvae to plant hosts (for feeding) and of adults (for oviposition), and the sensory mechanisms (including the active principles involved) underlying these behaviour patterns. These facets are a key to the problem of host specificity; they may also lead to the chemical (or other) sources of plant resistance to this pest. Reports mentioned at the Hyderabad Symposium on "Sorghum in Seventies", held in October 1971, show that tolerant varieties selected in India over several years from a large germplasm bank, all of the India rabi type, are primarily based on non-preference for oviposition. There is therefore some hope that truly shootfly-resistant sorghum varieties may well be developed in the future, with the cooperation of ICRISAT sorghum breeders.

D. Experimental Bases for Insect Mass-rearing and Screening for Resistance (IITA, ICRISAT, CIMMYT, IRRI)

30. Adequate techniques for measuring the degree of resistance in the world's germplasm for the various food crops (maize, sorghum, cowpeas, sweet-potatoes, rice, pigeon peas, etc.) presuppose the availability of insect material for the resistance tests, which have three special requirements:

- The insect material must be in sufficient quantity to permit a wide-ranging, statistically significant testing programme
- It must be of predicable uniform quality and at the right stage for the resistance being tested for
- It must be competitive with the wild type (if it is mass produced).

Mass-rearing of insects is therefore not only essential for most of the screening protocols for crop resistance, but it is equally essential that the mass-reared insects being used in the screening tests (whether in greenhouses, in screen-houses or in field plots) must be able to reproduce the normal situation in a field crop.

31. The ICIPE plans to develop mass-rearing methods up to a pilot stage, with appropriate monitoring systems for (a) ensuring that the insects are healthy, and (b) that they behave as normally as the wild population.

32. Rearing projects will be initiated for the following insects: cereal stem-borers (for CIMMYT, IITA, ICRISAT and IRRI), and for sweet potato weevils (IITA).

E. Tsetse Flies (ILRAD)

33. The ICIPE strategy is to collaborate closely with ILRAD and other agencies working towards the elimination of livestock trypanosomiasis (e.g. East African Trypanosomiasis Research Organization (EATRO), at Tororo, Uganda; the Nigerian Institute for Trypanosomiasis Research; and the FAO-supported project on Animal Trypanosomiasis Control in Dry Savannah Zone, which is being launched in 1976), but concentrate on research effort on the vector itself.

34. The ICIPE initiated research on tsetse biology more than three years ago. It has already made some notable achievements in elucidating the reproductive biology of tsetse flies, and in opening up new questions regarding the development of infective trypanosomes within the fly. This research is to be continued with the express purposes of opening up new avenues for vector control through the exploitation of the weak links in the biology of tsetse flies, or in explaining the epidemiological aspects of the parasite/vector/host interaction of importance to ILRAD.

35. The ICIPE plans to continue working on the following three large projects:

(a) Development and reproductive physiology of tsetse flies, particularly the important vectors G. pallidipes and G. morsitans. The type of questions that will be asked include: What factors lead to abortion? What are the critical factors that correlate intra-uterine larval feeding to lactation, and vice versa? How is lactation geared to the mother's food intake? In what way is intra-uterine larval growth and development geared to lactation? Which are the crucial factors in information exchange between mother and larva? What is the nature of the pacemaker mechanism that maintains cycles of pregnancy, parturition, and the subsequent events?

(b) Breeding biology of and mass-rearing technology for G. pallidipes. The first major step, now being studied, is the process of naturalisation to laboratory conditions of wild-caught tsetse flies, leading to successful feeding, mating, and breeding. This is a major initial barrier. The next step will be to establish a self-sustaining colony of G. pallidipes, which does not need to be replenished from time to time with new flies or pupae from the field

(c) Factors controlling infectivity of trypanosomes within the tsetse fly. Efforts will continue on the re-examination of the whole developmental life-cycle of the polymorphic trypanosomes - in the gut, in the haemocoele, and in the salivary glands - and to relate these cycles with the physiological and biochemcial events in the fly, and further to correlate these with the immunological loss of infectivity (in the gut) and its eventual re-acquirement (in the salivary glands). A chief question in regard to the latter is whether the antigens acquired by the trypanosomes while residing in the insect salivary glands are immunochemically the same antigens that the parasites previously acquired in the vertebrate host and subsequently lost in the first few hours of its sojourn in the insect. The answer to this question will form an important cornerstone to the whole problem of producing a practical vaccine against trypanosomiasis

(d) The nature of and factors that regulate vectorial capacity in the tsetse fly. These capacities are linked with endogenous factors of the tsetse fly itself (e.g. species, sex, age, physiological condition, and host preference), the trypanosome itself (e.g. the infective capacity of the parasite, the various strains and developmental forms, and the parasite population taken into the insect), and ecological factors (micro-climate, presence of appropriate host, etc.). Much of this study will require a great deal of field work, including new methods of sampling. For instance, how best can we sample the epidemiologically significant tsetse population, as opposed to the whole tsetse population?

ILRAD is particularly interested in projects outlined in (b) to (d).

F. Tick Vectors of Livestock Diseases

36. East Coast Fever (ECF) is a major disease of cattle, endemic in eastern Africa, from the southern border of the Sudan to Swaziland and from Zanzibar to Zaire. The parasitic agent concerned is Theileria parva, one of a group of related protozoal species affecting cattle as far afield as North Africa and the Middle East, which is transmitted by the brown ear-tick, Rhipicephalus appendiculatus, the most important field vector of this disease. Losses due to ECF are extremely serious; and it is estimated that in East Africa alone up to 500,000 calves are killed each year in the enzootic areas.

37. No specific treatment for the disease is presently tested and available, but the administration of broad-spectrum antibiotics during the incubation period can greatly reduce the severity of the infection, though risky in enzootic situations. It may also be noted that the UNDP/FAO Research on Tick-borne Diseases and Tick Control, based at the East African Veterinary Research Organization (EAVRO), Muguga (Kenya) has shown significan progress in developing immunization against T. parva by, for example, the innoculation of schizont-infected bovine lymphocyte cells grown in tissue culture;but these methods still need a great deal of futher development since cattle immunized in this way can withstand homologous challenge in a paddock artificially infested with the brown ear-tick infected with T. parva, but cannot apparently withstand uncontrolled and large natural challenge in field trials. ILRAD will be pursuing these immunological studies, and will be collaborating with the EAVRO team in this aspect of the ECF problem.

38. The ICIPE will be concentrating its efforts on elucidating the ecology and physiology of the tick vector, as it relates to the epidemiology of the disease and in order to open up new avenues for ECF elimination by vector control, other than by acaricides, for which many ticks are now showing resistance.

39. The ICIPE initiated the tick research programme more than three years ago. These initial studies have already shown that adult females of R. appendiculatus that had been feeding for several days secreted a volatile substance that induced fed, sexually-active males to move towards them and mate; chemical studies are now proceeding to identify the principles concerned. It has been shown that full engorgement is only triggered off by the mating process; and that the factors that are involved are partly mechanical ones (agitation during copulation) and partly chemical (an active principle included in the spermatophore transferred by the male during copulation); the significance of this finding is that it is during feeding that T. parva is transmitted: if the female tick is not mated, she will remain attached by her mouth for several weeks, salivating all the while, and thus facilitating the massive transfer of T. parva. On the ecological front, a long-term study of the changes in number of an experimental population of R. appendiculatus has been in progress for more than a year. Large numbers of juvenile ticks were placed on cattle that had been innoculated with ECF; the ticks engorged, detached and moulted; and the cattle died. When susceptible cattle were subsequently introduced into the experimental plot, they picked up many ticks, became infected and died. The tick population has become established in the field, and is now being used as a challenge for cattle immunised against East Coast Fever at EAVRO, and the ICIPE is continuing to study the population dynamics of this infected tick population. A control field, with no seeded ticks, and with cattle introduced only at intervals, is also being studied.

40. The ICIPE, closely interdigitating their work with that of EAVRO, plan to continue their investigations along the following lines:

(a) Ecology and population dynamics of the East Coast Fever vector species, R. appendiculatus, closely integrated with the epizootiological studies on East Coast Fever, both in experimental paddocks and free grazing land. These studies will be extended to the habitats of reservoir animals, e.g. the African buffalo (Syncerus caffer). The development of rational tick and disease control programmes demands the use of sophisticated studies on the population dynamics of the vector species and the infection rates of disease organisms within the vector populations. These studies are long-term, demanding at least 7 years for providing a reasonably comprehensive base-line data, with some idea of seasonal variations under a range of grazing ecosystems

(b) The importance of the different species of Thaileria in the East Coast Fever syndrome and the different tick vectors of these parasite species. It is known, for example, that T. mutans, which is transmitted by the tick Amblyomma cohaerens, is pathogenic to cattle and is involved in the East Coast Fever syndrome; but whereas this tick is very common on cattle in Ethiopia, it is rare on cattle in East Africa; the reason for this difference in ecology is not known. There is also need to investigate other Amblyomma species in East Africa as vectors of T. mutans and the ICIPE has already started on this

(c) The physiology of pheromone production and a detailed study of the associated tick behaviour

(d) The chemical characterization of the various pheromones and other active principles involved in aggregation, engorgement, mating, and other aspects of tick biology

(e) The hormonal factors responsible for tick development, and how these and other anologues might unbalance the normal sequence of development.

ILRAD has not yet decided on clear lines of its collaboration with the ICIPE on tick projects.

G. Research Units (All CGIAR Centres)

41. In addition to the normal support services of a biological research centre (e.g. library, insectaries, workshops, technical services, communication, and information), the ICIPE has from the start established three highly specialized laboratories (for chemical analysis and characterization, for structural studies of insect tissue, and for electrophysiological studies). These are staffed with highly qualified staff, at post-doctoral and graduate level, and equipped with sophisticated and relevant equipment. These laboratories provide specialized service to the core programmes; but they also conduct some research of their own which underpin the investigations of the target-insect oriented programmes.

42. The research support services are briefly summarized below:

(a) Chemistry and Biochemistry Research Unit (CBRU)

The chief mandate of the CBRU is to collaborate with the biologically-oriented research groups at the ICIPE in solving chemical and biochemical problems, by bringing to bear advanced physico-chemical methods, isolation techniques, purification methods, techniques for chemical structural elucidation, and biosynthetic studies to characterize the natural regulators of insect life, active principles, and other natural products, - e.g. feeding attractants, trail and sex pheromones, and defensive secretions.

(b) Sensory Physiology Research Unit (SPRU)

The analysis of the structure and function of chemoreceptors - whether for olfaction or taste - constitutes one of the most urgent tasks of the SPRU in relation to the several studies already being undertaken at the ICIPE on insect chemical communication - in relation, for instance, to plant resistance studies, termite recruitment, and pheromonal biology. Secondly, in combination with clear-cut behavioural tests, electrophysiological bioassays can greatly help the attainment of a more rapid identification of biologically active substances employed in mating, food-plant selection, oviposition-site identification, host detection, and host finding. Finally, there are other sensory systems in the target insects which can be analysed profitable: for instance, the auditory system in tsetse flies and moths.

The Unit will be vital in an analysis of the plant-resistance factors in the various crops mentioned in the plant-resistance programme.

(c) Histology and Fine Structure Research Unit (HFSRU)

The HFSRU is staffed by experienced personnel in histological, histochemical, autoradiographic, and electron-microscopic techniques whose chief mandate is to give assistance to the core programmes on questions demanding fine-structural information, at a resolution approaching the molecular level, for instance, a structural study of the chemoreceptors of ticks, tsetse flies, and moth caterpillars.

H. Other ICIPE Core Programmes

43. The ICIPE has, as its core programmes on its own funding through other donors (e.g. UNDP, USAID, the Swiss Technical Cooperation Agency, and ODM), studies on the following areas:

- Ecological and physiological studies on harvester termites in semi-arid savannah areas
- Mosquito population biology and genetics as it relates to the vectors of filariasis and malaria
- African armyworm, its migration ecology, outbreak phenomena, and behaviour in relation to food selectivity.

44. These programmes have been detailed in the original proposal to TAC, and will not be elaborated further here. However, it is noteworthy that as a result of recommendations by a Working Group on Mosquitoes appointed by the ICIPE Board in June 1975, the ICIPE has now decided to phase out its work on yellow-fever mosquito vectors by the end of 1976, and to bring into being in January 1977 new programmes on the vector biology of malaria and filariasis mosquito-carriers, as well as the tsetse vectors of trypanosomiasis.

III. RESEARCH AND TECHNICAL SUPPORT SERVICES

45. Several services, of a scientific and technical support nature, have been found by ICIPE experience to be essential for its effectiveness, as follows:

- Insect and Animal Breeding Service *
- Laboratory Service *
- Workshops *
- Field Station Management *
- Outreach Management Service
- Library and Documentation Service *
- Statistical and Computer Service

(* Services already fully or partly established)

46. The Statistical and Computer Service requires, a great deal more planning, and will not be operated until at least mid-1978. The already established services will be outlined briefly below.

A. Insect and Animal Breeding Service

47. The task of this unit is to establish and maintain a large, self-producing colony of each of the target insect species for experimental purposes, and of other insect species needed for bioassays and similar work. For blood-sucking arthropods, this requires that the unit also maintains colonies of the appropriate host animals. For plant-feeding insects, it may require the provision of standardized plant material grown in greenhouses, etc. Experimental, as opposed to routine, breeding of insects is the responsibility of a separate programme (see II. D above).

48. The following colonies of insects are being routinely mass-reared by the IABS:

- Tsetse flies: G. morsitans and G. austeni
- The brown ear-tick, R. appendiculatus
- The soft tick, Ornithodoros moubata (for bioassay work)
- The sorghum stem-borer, C. partellus
- The wax-moth, Galleria mellonella (for bioassay work)
- The African armyworm, Spodoptera exempta.

49. It is anticipated that the sorghum shootfly, on which experimental breeding work is now being conducted, and other major target insects named in the newer programmes on plant resistance and stem-borers, will be mass-reared by the Unit in the near future. Radically new and properly designed facilities are urgently needed for this critical support service, and these will be placed in a new site.

B. Laboratory Service

50. This service includes the management of the laboratory facilities, the operation of several specialised services (e.g. bioassay, electrophoresis, radioisotope and radiation, and photographic services). It supports most of the research programmes across the board.

C. Workshops

51. The ICIPE vitally needs to maintain a first-class electronic workshop for servicing the many electoric and other sophisticated equipment and to assist in the design and fabrication of new equipment, which is a constant need for electrophysiological, fine-structural, and chemical research going on at the Centre. The latter also needs mechanical and wood-working workshops. All these facilities already exist at the ICIPE, although in miniature form only. It is essential that these facilities be expanded to meet the enlarged needs of the research programmes and support services, the maintenance of the physical plant of the ICIPE, and the routine servicing of vehicles.

D. Field Station Management

52. Ecological work at the ICIPE is the main anchor for much of the other multidisciplinary research being conducted on the target insects. Although the ICIPE already has a number of mobile laboratories for some of its field work, the longer-term field ecological investigations do require more or less permanent residence in the field. Another consideration is the need for varietal trials (e.g. for crop resistance to insect attack) under tropical field conditions. Finally, there is need for investigations of various novel approaches to pest management. Consequently, the need for field station facilities in paramount.

53. The ICIPE has decided to establish its main Field Station at Mbita Point, near Homa Bay, on the shores of Lake Victoria. The station will be vital for ecological studies on the sorghum shootfly, the cereal borers of sorghum and maize, legume pod-borers, the armyworm, ticks, and tsetse flies (particularly G. pallidipes). While this station is being planned and eventually built during 1976-1978, field work is being carried out from field accommodation provided by the Ministry of Agriculture, some 100 km away, but still near Lake Victoria (at Kibos). Preliminary planning has already been accomplished, which will soon be followed by more detailed agronomic, physical, and architectural planning. It is planned to start construction in the new year.

54. The ICIPE has smaller field stations at Kajiado (for termite ecological research under semi-arid conditions) and at Mombasa (for mosquito ecological research). There are no plans at present for making

them full-fledged field stations.

E. Outreach Management Service

55. The coordination of ICIPE's own research activities with those being done cooperatively with the CGIAR Centres (and other institutes, e.g EAVRO and EATRO) requires close management by a senior scientist. The ICIPE has a full-time Deputy Director (Research) whose main function is to do just that, as well as coordinating in-house research. Several of ICIPE's scientific staff will be working in the cooperating institutes for shorter or longer periods of time.

F. Library and Documentation Service

56. A good library for literature on the target insects on which the ICIPE is working does not exist in East Africa. The Centre has already started a small reference library on these and related problems. At the same time, the ICIPE has now decided, with the assistance of a bilateral donor, to establish a Pest Management Documentation unit in the Centre.

IV. COOPERATIVE PROGRAMMES WITH CGIAR CENTRES AND APPLIED INSTITUTES

A. Cooperative Programme with CGIAR

57. The ICIPE proposes that collaboration between it and the CGIAR Centres be considerably strengthened, and that its pest research programmes interdigitate with the Centres' own concerns in this area, as indicated in Section II above. In the first instance, in 1977, this close relationship will involve IITA, IRRI, ICRISAT, and ILRAD; but it is hoped that it will encompass the other Centres as new needs arise and new opportunities for collaboration appear.

58. It has already been suggested that ICIPE scientists spend a considerable period of time at the beginning of this collaborative period to have first-hand experience with the crop material (and its germplasm) and the important pest problems. It is envisaged that the ICIPE scientists will return to the Centres from time to time to review their research orientation with the changing agronomic situation. In the case of IRRI, where rice insects in Asia may well not be found in Africa, much of the work will be done in IRRI.

59. It is suggested that the Centres' own entomologists may find the ICIPE an excellent reference point for obtaining new ideas for testing in their own institutions. Such a feedback mechanism will form an organic linkage between the ICIPE and the CGIAR Centres; and it is proposed that the Centres' entomologists be appointed to research associateship status at the ICIPE to enable them to undertake working visits at the ICIPE for short or long periods.

B. Cooperative Programmes at National and Regional Levels

60. The ICIPE already maintains an extensive network of liaison with applied research institutes in Africa and elsewhere for work on ICIPE target insects. These linkages need to be strengthened, as the ICIPE's own foundation becomes firmed up. Such institutes include the following, and many others:

The East African Veterinary Research Organization (EAVRO), Muguga, Kenya
East African Agriculture and Forestry Research Organization (EAAFRO), Muguga, Kenya
East African Trypanosomiasis Research Organization (EATRO), Tororo, Uganda
Tropical Pesticides Research Insitute, Arusha, Tanzania
Ministry of Agriculture, Kenya
University of Nairobi, Kenya
National Council for Scientific Research, Lusaka, Zambia
University of Ibadan, Nigeria
Institute of Pathobiology, Addis Ababa, Ethiopia
Tsetse Research Laboratory, Bristol, England
CSIRO, Canberra, Australia.
Centre for Overseas Pest Research, London, England

61. New linkages now need to be developed to reflect the needs of the new research programmes recently approved (sorghum shootfly, stem-borers, and plant resistance). The Tanzania Food Crops Research project, recently initiated jointly by IITA, ICRISAT and CIMMYT, is such a new and important linkage. The linkages are essential if the ICIPE is to ensure that its findings find practical application at the farmer's level.

C. Training Programmes

62. The ICIPE puts very high premium on the training of its technical staff, on the training of young graduate scientists from Africa and other LDCs, the training of young postdoctoral scientists, and the provision of opportunities of young African scientists already serving in other institutions coming to the ICIPE over a three-year period for a total time of 12 months to conduct important research on an insect problem relevant to the ICIPE core programmes and then returning to their own institutions to continue their professional. All these various devices are to permit the rapid build up of a scientific and technical capability in LDCs in pest research oriented to important development problems.

63. The ICIPE has made a start in this direction. The establishment of adequate physical facilities at the ICIPE will enable it to intensity this commitment.

D. Study Workshops and Seminars

64. The most important ICIPE conference has become the Annual Research Conference, at which the whole ICIPE scientific community (and including the Policy Advisory Committee) reviews the research progress of the year and establish new lines of concentrated research. These conferences have become seminal, and will be retained as an institutional mechanism for monitoring ICIPE research and training activities.

65. Weekly seminars on specialized topics have also become a feature of ICIPE scientific life from the very beginning, and has formed one of the linkages with the scientific community in East Africa.

66. The ICIPE has now organized or sponsored two study workshops - on the armyworms (January 1975) and on tsetse breeding as related to the sterile-male control technique (March 1975). In these small workshops, a small group of actively involved field and laboratory workers come together to discuss the state of the particular problem and plan future cooperative work. They have been enormously successful; and the ICIPE is now planning one for each year on a special problem related to ICIPE's core activities.

V. INSECT RESEARCH NETWORK

A. Collaboration with Other Insect Research Laboratories

67. One of the major intellectual resources of the ICIPE are the Research Consultants or Visiting Senior Scientists (formerly known as "Directors of Research"), who are world authorities in their own area of insect science, and who have therefore an excellent research laboratory in their home base, of which they are the recognized leader. These research laboratories, which collaborate with the ICIPE in research and training, therefore form - together with the ICIPE itself - a formidable network of research laboratories which has become pre-eminent in the insect research world. The network is not a fixed entity: it takes on new dimensions with the changes in the persons appointed as Research Consultants, and is therefore responsive to new ideas in the ICIPE. Above all, it ensures that the ICIPE scientific staff is constantly in communication with the latest developments in their own specialized and related areas. This is an unusual circumstance in a research laboratory in most LDC's and gives the ICIPE great strength.

B. Sharing of Facilities

68. The ICIPE and ILRAD, because of their close geographical proximity, their common orientation to problem-solving rather than crop-production, and their interdigitating interest in livestock trypanosomiasis and East Coast Fever, have common interests, which are strengthening as ILRAD staff come into position. The managment of the two institutions have recognized this factor, and have started exploring facilities that the two institutions could, with profit, share. These include the following items:

- The sharing of a radiation unit, to be established by ILRAD in the next two years
- The sharing of the Histology and Fine Structure Research Unit, established and already operational at the ICIPE, until such time that ILRAD find its work volume such as to need their own facility
- The organization of joint study workshops, such as the one being planned for September/ October 1976 on tsetse ecology and behaviour
- The sharing of workshop expertise in the servicing of research equipment.

It is possible other joint interests will surface at a later date. The two managements will certainly want to consider them carefully, and recommend appropriate action.

VI. ORGANIZATION AND RECRUITMENT

69. Criticism has been made on the present administration and staffing of the ICIPE along the following major lines:

- The need to strengthen the management of the ICIPE by the appointment of a full-time Director. So far, he holds a faculty position in the University of Nairobi
- It is unrealistic to expect Research Consultants, who usually visit Nairobi only once or twice a year, to provide the necessary continuity in the leadership of the research programmes

- The present policy of appointing principal scientific staff for only 2-4 years makes for too rapid a turnover, and may lead to unnecessary interruption of important work (especially in the field of ecology) or the loss of research support staff (who require long technical training and experience).

70 As indicated to the Technical Advisory Committee of the CGIAR during their meeting in Rome in January 1975, the ICIPE Board was willing to make some changes in its organization, management, and recruitment policies to meet some of these vital matters of policy. In this task, the ICIPE was considerably assisted by the recommendations of a Visiting Group (headed by Professor Harvey Brooks of Harvard), appointed by the Board in September 1974, which reported in May 1975 on the progress of the scientific research and training activities of the ICIPE.

71. The Board has now taken important decisions in these matters, which can be summarized as follows:

(a) Professor Thomas R. Odhiambo is now, since January 1976, the full-time Director of the ICIPE

(b) The Board has taken the decision to appoint a few very senior scientists, who will be resident at the ICIPE, and give coordination to the research programmes and research support units. A number of the Research Consultants will continue to give scientific guidance to the resident scientific staff, particularly in relation to specialized disciplines. These changes are likely to give firmer research leadership and continuity at the ICIPE.

(c) Recruitment tenures will now be more flexible, permitting longer and renewable contracts according to the project needs and the continued excellence of the research worker concerned.

VII. CONTRACTUAL ARRANGEMENTS

72. The associated membership status being considered for the ICIPE vis-a-vis the CGIAR is a novel one, and needs some close examination.

A. Funding and Accountability

73. The ICIPE is now an on-going vigorous institution. But it is clear also that it cannot reach its optimum potential nor perform the contractual work it is proposed it will do on behalf of the CGIAR Centres, unless it is given considerable physical facilities (in terms of laboratory buildings, administrative accommodation, training facilities, field station facilities, etc.) to match these research objectives. Furthermore, it would seem that the best method of channelling grants for this capital development would

system should be developed for having the Centres agree to each of the programmes as a whole and have this research programme package negotiated by the CGIAR on behalf of the Centres. A contract agreement between the CGIAR and the ICIPE would then be the result.

75. We believe that this contractual arrangement would give to the ICIPE both the stability and simplicity of operation that it needs in order to carry out its mandate in the area of pest management.

76. The ICIPE will, of course, raise from other sources funds that it may require for its other core programmes - mainly the more speculative research projects on insects (e.g. population diversity in G. pallidipes), research projects specifically contracted by other agencies (e.g. the role of termites in the savannah ecosystem), and research on tropical pests of medical importance (e.g. mosquito vectors). In these cases, the ICIPE will levy an appropriate level of overhead charge to finance management and similar costs.

77. A crucial question arises as to the accountability of the ICIPE to the CGIAR. It is proposed that this problem be resolved in the following manner:

- The ICIPE should report its research progress and its research needs at its Annual Research Conference, at which representatives of the cooperating centres will be present. (This is in fact already happening through the UNDP/ICIPE Policy Advisory Committee, which meets in Nairobi at this time each year)
- The Technical Advisory Committee of the CGIAR should be able to conduct reviews of the research and training activities of the ICIPE, as it does from time to time those of the other Centres
- The ICIPE should submit to the audit requirements laid down by the CGIAR
  The CGIAR should, if it so desires, nominate its representatives on the ICIPE Board, either as full members or observers.

B. Basic Financial Support

78. The following Tables gives budgetary requirements for the entire ICIPE programmes and capital needs in 1977. It also indicates the level of request from the CGIAR system for the contractual research for the four institutes, and the contributions the ICIPE expects from other donor organizations.

79. Budgetary requirements for 1978 and subsequent yearly forecastes for the following four years will be provided in March 1977, when the total needs of the ICIPE and its collaborating partners is better known.

80. The budgetary provisions have been shown in U.S.Dollars, and arranged according to the CGIAR requirements. The needs for 1977 are clear, and have already been approved by the ICIPE Governing Board. The budgetary figures for 1978-1982 will be considered by the Board in February 1977 before their presentation to the TAC/CGIAR.

81. It should be particularly noted that the BOARD has recently approved ICIPE's capital development plans which includes the establishment of new laboratory and support buildings in a new 20-acre site at Salopia Farm, in Nairobi, recently granted by the Kenya Government. Such a plan will give the ICIPE much needed room for its new physical facilities, while for other uses (mainly training). A great

proportion of the needed development funds (about 98%) is being negotiated with a donor, while the ICIPE is requesting the CGIAR for \$ 1.5 million to complement this capital development fund. It is hoped that master-planning of these developments will start early next year for the Nairobi buildings. In regard to programme costs (of a total of \$ 5,336,000 for 1977), we are requesting the CGIAR for a grant of \$1,991,200 thus leaving the ICIPE to raise the rest of the funds (\$ 3,424,800). The ICIPE is confident that it will be able to raise this amount before the end of this year. Work that has been agreed upon by the ICIPE and its CGIAR Centre partners (IRRI, IITA, ICRISAT, and ILRAD) is crucial; and it is to be very much hoped that the TAC/CGIAR will recommend the initiation of these projects in January 1977 and to agree to their funding.

TABLE I

1977 BUDGET

SUMMARY OF COSTS BY PROGRAMME AND ACTIVITY

(US $ Thousands)

	TOTAL		CGIAR	OTHERS
	M/Y	COST		
RESEARCH PROGRAMMES				
I. CROP PESTS				
1. Bases of Plant Resistance	4	395.5	395.5	-
2. Exp. Bases for Insect Mass-Rearing and Screening	1	135.8	135.8	-
3. Borers	2	208.6	208.6	-
4. Sorghum Shootfly	2	246.2	21.1	225.1
II. LIVESTOCK PESTS				
1. Tsetse	3	340.0	85.0	255.0
2. Hard Ticks	3	263.9		263.9
III. MEDICAL VECTORS	1	142.1		142.1
IV. TERMITES	1	216.4		216.4
V. AFRICAN ARMYWORM	2	249.0		249.0
IV. RESEARCH UNITS				
1. Chemistry and Biochemistry	3	290.1	200.1	90.0
2. Histology and Fine Structure	2	224.7	168.5	56.2
3. Sensory Physiology	2	142.0	106.5	35.5
RESEARCH AND TECHNICAL SUPPORT SERVICES				
1. Insect and Animal Breeding	1	255.1	119.1	136.0
2. Workshops	-	71.2		71.2
3. Laboratory Services	1	148.6	111.5	37.1
4. Field Stations Management	1	190.3	95.1	95.2
5. Outreach Management Service	1	115.0	86.3	28.7
6. Library and Documentation Service	-	148.6		148.6
TRAINING AND COMMUNICATIONS				
1. Training	1	251.9		251.9
2. Communication and Information	-	140.2		140.2
3. Conferences and Study Workshops	-	180.2		180.2
ADMINISTRATION				
I. GENERAL ADMINISTRATION				
1. Board and Committees	-	150.2		150.2
2. Office of the Director	1	168.2		168.2
3. Accounting	1	153.0		153.0
4. Purchasing and Stores	-	40.8		40.8
5. Personnel and Office Management	1	112.2		112.2
II. GENERAL OPERATIONS				
1. Physical Plant Services		157.5		
2. Transport Unit		92.3	178.1	178.1
3. Utilities		106.4		
	34	5,336.0	1,911.2	3,424.8

TABLE II

1977 BUDGET

(US $ Thousands)

		COST	PERCENT
A.	SUMMARY OF COSTS BY OBJECT OF EXPENDITURE		
	Personnel Costs	2,708.6	50.8
	Consultations	70.1	1.3
	Travel	240.6	4.5
	Materials, Services and Expenses	787.0	14.7
	Equipment	663.2	12.4
	Vehicles	259.5	4.9
	Training/Conferences	264.4	5.0
	Contingency/Provision for Price Change	342.6	6.4
		5,336.0	100.0
B.	SUMMARY OF COSTS BY ACTIVITY		
	Research Programmes	2,854.3	53.5
	Research and Technical Support	928.8	17.4
	Training and Commuciations	572.3	10.7
	Administration	980.6	18.4
		5,336.0	100.0

C. CAPITAL DEVELOPMENT

	TOTAL	1977		1978	1979	1980
		CGIAR	OTHERS			
ICIPE Headquarters	13,463.5	1,500.0	2,763.0	6,395.0	2,132.5	673.0
Mbita Field Station	1,124.5	-	712.0	356.0	56.5	-
Kajiado Field Station	709.0	-	337.0	337.0	35.0	-
	15,297.0	1,500.0	3,812.0	7,088.0	2,224.0	673.0
		5,312.0				

TABLE III

1977 BUDGET SUMMARY

(US $ Thousands)

	TOTAL	CGIAR	OTHERS
OPERATING	5,336.0	1,911.2	3,424.8
CAPITAL BUDGET	5,312.0	1,500.0	3,812.0
	10,648.0	3,411.2	7,236.8